skilled positions, such as mold and model maker. Furthermore, small manufacturers, which typify the industry, will have an increasingly difficult time competing with the larger manufacturers when it comes to supplying large retailers. Because of recent international trade agreements, exports are increasing modestly as manufacturers become more competitive in foreign markets. However, imports from foreign manufacturers are increasing more rapidly than exports due to these same agreements.

Earnings

Median annual earnings for jewelers and precious stone and metal workers were $23,820 in 1998. The middle 50 percent earned between $17,110 and $32,540. The lowest 10 percent earned less than $12,670 and the highest 10 percent earned over $41,160.

According to the Manufacturing Jewelers and Suppliers of America, the median average hourly wage of jewelers in companies with more than 10 employees was $13.62 in 1998. Beginners in jewelry factories usually start at considerably less pay than experienced workers do. As they become more proficient, they receive raises.

Most jewelers enjoy a variety of benefits including reimbursement from their employers for work-related courses and discounts on jewelry purchases.

Related Occupations

Jewelers and precious stone and metal workers do precision handwork. Other skilled workers who do similar jobs include polishers, dental laboratory technicians, hand engravers, and watch makers and repairers.

Sources of Additional Information

Information on job opportunities and training programs for jewelers is available from:

☛ Gemological Institute of America, 5345 Armada Dr., Carlsbad, CA 92008.

☛ California Institute of Jewelry Training, 5800 Winding Way, Carmichael, CA 95608.

General career information is available from:

☛ Jewelers of America, 1185 Avenue of the Americas, 30th Floor, New York, NY 10036.

☛ Manufacturing Jewelers and Suppliers of America, 1 State St., 6th Floor, Providence, RI 02908-5035.

To receive a list of technical schools accredited by the Accrediting Commission of Career Schools and Colleges of Technology which have programs in jewelry design, contact:

☛ Accrediting Commission of Career Schools and Colleges of Technology, 2101 Wilson Blvd., Suite 302, Arlington, VA 22201.

Machinists and Numerical Control Machine Tool Programmers

(O*NET 25111 and 89108)

Significant Points

- Formal training in high schools, vocational schools, or community colleges is typical; many entrants have previously worked as machine tool operators or setters.
- Job opportunities will be excellent, as employers continue to report difficulties in finding workers with the necessary skills and knowledge.

Nature of the Work

Machinists use machine tools, such as lathes, drill presses, and milling machines to produce precision metal parts. Although they may produce large quantities of one part, precision machinists often produce small batches or one-of-a-kind items. They use their knowledge of the working properties of metals and their skill with machine tools to plan and carry out the operations needed to make machined products that meet precise specifications.

Before they machine a part, machinists must carefully plan and prepare the operation. These workers first review blueprints or written specifications for a job. Next, they calculate where to cut or bore into the workpiece, how fast to feed the metal into the machine, and how much metal to remove. They then select tools and materials for the job, plan the sequence of cutting and finishing operations, and mark the metal stock to show where cuts should be made.

After this layout work is completed, machinists perform the necessary machining operations. They position the metal stock on the machine tool—drill presses, lathes, milling machines, or others—set the controls, and make the cuts. During the machining process, they must constantly monitor the feed and speed of the machine. Machinists also ensure that the workpiece is being properly lubricated and cooled, because the machining of metal products generates a significant amount of heat.

Some machinists, often called production machinists, may produce large quantities of one part, especially parts requiring complex operations and great precision. For unusually sophisticated procedures, expensive machinery is used. Usually, however, large numbers of parts requiring more routine operations are produced by metalworking and plastics-working machine operators. (See the statement on metalworking and plastics-working machine operators elsewhere in the *Handbook*.) Other machinists do maintenance work—repairing or making new parts for existing machinery. To

It takes several years to become a highly skilled machinist.

repair a broken part, maintenance machinists may refer to blueprints and perform the same machining operations that were needed to create the original part.

Increasingly, the machine tools used to produce metal parts are computer numerically controlled (CNC)—that is, they contain computer controllers that direct the machine's operations. The controller reads a program—a coded list of the steps necessary to perform a specific machining job—and runs the machine tool's mechanisms through the steps. The introduction of CNC machine tools has changed the nature of the work of machinists. These machines enable machinists to be more productive and to produce parts with a level of precision that is not possible with traditional machining techniques. Furthermore, because precise movements are recorded in a program that can be saved and used again in the future, they allow this high level of precision to be consistently repeated. CNC machine tools also allow various functions to be performed with one setup, thereby reducing the need for additional, labor-intensive setups.

The quality of the products these machines produce depends largely on the programs, which may be produced by machinists or by CNC machine tool programmers (CNC programmers). CNC programmers begin as machinists do—by analyzing blueprints, computing the size and position of the cuts, determining the sequence of machine operations, selecting tools, and calculating the machine speed and feed rates. They then write the program in the language of the machine's controller and store it. Skilled machinists may also do programming. In fact, as computer-aided manufacturing (CAM) software becomes more user-friendly and CNC machines are more widely used, machinists are increasingly expected to perform this function.

Machinists work alone or with CNC programmers to check new programs and ensure that machinery will function properly and the output will meet specifications. Because a problem with the program could damage costly machinery and cutting tools, computer simulations may be used instead of a trial run to check the program. If errors are found, the program must be changed and re-tested until the problem is resolved. In addition, growing connectivity between computer-aided design software and CNC machine tools is raising productivity by automatically translating designs into instructions, which are understood by the computer controller on the machine tool. These new CAM technologies enable programs to be easily modified for use on other jobs with similar specifications, thereby reducing time and effort.

Working Conditions

Most machine shops are well lit and ventilated. Nevertheless, working around high-speed machine tools presents certain dangers, and workers must follow safety precautions. Machinists wear protective equipment such as safety glasses to shield against bits of flying metal and earplugs to dampen machinery noise. They must also exercise caution when handling hazardous coolants and lubricants. The job requires stamina, because machinists stand most of the day and at times may need to lift moderately heavy workpieces.

CNC programmers work in offices that typically are near, but separate from, the shop floor. These work areas are usually clean, well lit, and free of machine noise.

Most machinists and CNC programmers work a 40-hour week. Evening and weekend shifts are becoming more common as companies justify investments in more expensive machinery by extending hours of operation. Overtime is common during peak production periods.

Employment

Machinists and CNC programmers held about 434,000 jobs in 1998, with the vast majority being machinists. Most machinists work in small machining shops or in manufacturing firms that produce durable goods, such as metalworking and industrial machinery, aircraft, or motor vehicles. Maintenance machinists work in most industries that use production machinery. Although machinists and CNC programmers work in all parts of the country, jobs are most plentiful in the Northeast, Midwest, and West Coast where manufacturing is concentrated.

Training, Other Qualifications, and Advancement

A high school or vocational school education, including courses in mathematics, blueprint reading, metalworking, and drafting, is generally a prerequisite for becoming a machinist or CNC programmer. Basic knowledge of computers and electronics is also helpful because of the increased use of computer-controlled machine tools. Experience with machine tools is extremely important. In fact, many entrants to these occupations have previously worked as machine tool operators or setters. Persons interested in becoming machinists or CNC programmers should be mechanically inclined, able to work independently, and able to do highly accurate work that requires concentration and physical effort.

Machinist training varies from formal apprenticeship and postsecondary programs to informal on-the-job training. Apprentice programs consist of shop training and related classroom instruction. In shop training, apprentices learn filing, handtapping, and dowel fitting, as well as the operation of various machine tools. Classroom instruction includes math, physics, blueprint reading, mechanical drawing, and shop practices. In addition, as machine shops have increased their use of computer-controlled equipment, training in the operation and programming of CNC machine tools has become essential. Such formal apprenticeships are relatively rare, however, as a growing number of machinists and CNC programmers receive most of their formal training from community or technical colleges.

To boost the skill level of machinists and to create a more uniform standard of competency, a number of training facilities and colleges have recently begun implementing curriculums incorporating national skills standards developed by the National Institute of Metalworking Skills (NIMS). After completing such a curriculum and passing a performance requirement and written exam, a NIMS credential is granted to trainees, providing formal recognition of competency in a metalworking field. This designation can lead to advancement or confirmation of skills during a job search.

Qualifications for CNC programmers vary widely depending upon the complexity of the job. Basic requirements parallel those of machinists. Employers often prefer skilled machinists or those with technical school training. For some specialized types of programming, such as with complex parts for the aerospace or shipbuilding industries, employers may prefer individuals with a degree in engineering.

For those entering CNC programming directly, a basic knowledge of computers and electronics is necessary, and experience with machine tools is extremely helpful. Classroom training includes an introduction to numerical control, the basics of programming, and more complex topics, such as computer-aided manufacturing. Trainees start writing simple programs under the direction of an experienced programmer. Although machinery manufacturers are trying to standardize programming languages, there are numerous languages in use. Because of this, CNC programmers should be able to learn new programming languages.

As new automation is introduced, machinists and CNC programmers normally receive additional training to update their skills. This training is usually provided by a representative of the equipment manufacturer or a local technical school. Some employers offer tuition reimbursement for job-related courses.

Machinists and CNC programmers can advance in several ways. Experienced machinists may become CNC programmers, and some are promoted to supervisory or administrative positions in their firms. A few open their own shops.

Job Outlook

Despite slower than average employment growth, job opportunities will be excellent for machinists, as employers continue to report difficulties in finding workers with the necessary skills and knowledge to fill machining and CNC programming openings. Many job openings

will arise each year from the need to replace experienced machinists and programmers who transfer to other occupations or retire. The number of openings for machinists is expected to be greater than the number of openings for CNC programmers, primarily because the machinist occupation is larger.

Employment of machinists and CNC programmers is expected to grow more slowly than the average for all occupations through 2008. In spite of a robust economy, rising productivity among machinists and CNC programmers will limit their employment growth. Productivity gains are resulting from the expanded use of computer-controlled machine tools and new technologies, such as high-speed machining, which reduce the time required for machining operations. This allows fewer machinists to accomplish the same amount of work previously performed by more workers. Technology is not expected to affect the employment of machinists as significantly as most other production occupations, however, because many of the unique operations performed by machinists cannot be efficiently automated. In addition, firms are likely to retain their most skilled workers to operate expensive new machinery.

Despite increased use of CNC machine tools on shop floors, CNC programmers are also projected to grow more slowly than the average for all occupations through 2008. As advanced machine tool technology allows some programming and minor adjustments to be performed on the shop floor by machinists, tool and die makers, and machine operators, fewer CNC programmers will be needed. In addition, the demand for CNC programmers will be negatively affected by the increasing use of software that automatically translates part and product designs into CNC machine tool instructions.

Employment levels in these occupations are influenced by economic cycles—as the demand for machined goods falls, machinists and CNC programmers involved in production may be laid off or forced to work fewer hours. Employment of machinists involved in plant maintenance, however, is often more stable, because proper maintenance and repair of costly equipment remain vital concerns, even when production levels fall.

Earnings

Median annual earnings of machinists were $28,860 in 1998. The middle 50 percent earned between $22,670 and $36,100. The lowest 10 percent had earnings of less than $17,800, while the top 10 percent earned over $42,480. Median annual earnings in the manufacturing industries employing the largest number of machinists in 1997 were:

Aircraft and parts	$32,200
Metalworking machinery	28,300
Industrial machinery, not elsewhere classified	26,500

Median annual earnings of CNC programmers were about $40,490 in 1998. The middle 50 percent earned between $33,230 and $49,620. The lowest 10 percent had earnings of less than $27,170, whereas the top 10 percent earned over $72,290.

Related Occupations

Occupations most closely related to that of machinist and CNC programmer are other machining occupations. These include tool and die maker, metalworking and plastics-working machine operator, tool planner, and instrument maker. Workers in other occupations that require precision and skill in working with metal include blacksmiths, gunsmiths, locksmiths, metal patternmakers, and welders.

CNC programmers apply their knowledge of machining operations, metals, blueprints, and machine programming to write programs that run machine tools. Computer programmers also write detailed programs to meet precise specifications.

Sources of Additional Information

For general information about this occupation, contact:

☛ The Precision Machined Products Association, 6700 West Snowville Rd., Brecksville, OH 44141. Internet: **http://www.pmpa.org**

☛ The National Tooling and Machining Association, 9300 Livingston Rd., Fort Washington, MD 20744. Internet: **http://www.ntma.org**

Metalworking and Plastics-Working Machine Operators

(O*NET 89132, 91102, 91105, 91108, 91111, 91114A, 91114B, 91117, 91302, 91305, 91308, 91311, 91314, 91317, 91321, 91502, 91505, 91508, 91714, 91902, 91905, 91908, 91911, 91917, 91921, 91923, 91926, 91928, 91932, and 91938)

Significant Points

- A few weeks of on-the-job training is sufficient for most workers to learn basic machine operations, but several years are required to become a skilled operator.
- Projected employment change varies by type of job. Employment of most manual machine tool operators is expected to decline, while that of multiple and computer-controlled machine tool operators will grow.

Nature of the Work

Consider the parts of a toaster, such as the metal or plastic housing or the lever that lowers the toast. These parts, and many other metal and plastic products, are produced by metalworking and plastics-working machine operators. In fact, machine tool operators in the metalworking and plastics industries play a major part in producing most of the consumer products on which we rely daily.

In general, these workers can be separated into two groups—those who set up machines for operation and those who tend the machines during production. Set-up workers prepare the machines prior to production and may adjust the machinery during operation. Operators and tenders, on the other hand, primarily monitor the machinery during operation, sometimes loading or unloading the machine or making minor adjustments to the controls. Many workers set up and operate equipment. Because the set-up process requires an understanding of the entire production process, setters usually have more training and are more highly skilled than those who simply operate or tend machinery. As new automation simplifies the setup process, however, less skilled workers are also increasingly able to set up machines for operation.

Setters, operators, tenders, and set-up operators are usually identified by the type of machine with which they work. Some examples of specific titles are screw machine operator, plastics-molding machine set-up operator, punch press operator, and lathe tender. Job duties usually vary based on the size of the firm and on the type of machine being operated. Although some workers specialize in one or two types of machinery, many are trained to set up or operate a variety of machines.

Metalworking machine setters and operators set up and tend machines that cut and form all types of metal parts. Traditionally, set-up workers plan and set up the sequence of operations according to blueprints, layouts, or other instructions. They adjust speed, feed, and other controls, choose the proper coolants and lubricants, and select the instruments or tools for each operation. Using micrometers, gauges, and other precision measuring instruments, they may also compare the completed work with the tolerance limits stated in the specifications.

Although there are many different types of metalworking machine tools that require specific knowledge and skills, most operators perform similar tasks. Whether tending grinding machines that remove excess material from the surface of machined products or presses that extrude metal through a die to form wire, operators usually perform simple, repetitive operations that can be learned quickly. Typically, these workers place metal stock in a machine on which the operating specifications have already been set. They may watch one or more machines and make minor adjustments according to their instructions. Regardless of the type of machine they operate, machine tenders usually depend on skilled set-up workers for major adjustments when the machines are not functioning properly.

Plastics-working machine operators set up and tend machines that transform plastic compounds—chemical-based products that can be